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Published:

- *with international search report*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

Title: IMAGING SYSTEM AND METHODOLOGY EMPLOYING RECIPROCAL
SPACE OPTICAL DESIGN

5

RELATED APPLICATION

This application claims the benefit of U.S. Patent Application Serial No.
09/900,218, which was filed July 6, 2001, and entitled IMAGING SYSTEM AND
METHODOLOGY EMPLOYING RECIPROCAL SPACE OPTICAL DESIGN.

10

TECHNICAL FIELD

The present invention relates generally to image and optical systems, and more
particularly to a system and method to facilitate imaging performance *via* an image
transfer medium that projects characteristics of a sensor to an object field of view.

15

BACKGROUND OF THE INVENTION

Microscopes facilitate creating a large image of a tiny object. Greater
magnification can be achieved if the light from an object is made to pass through two
lenses compared to a simple microscope with one lens. A compound microscope has two
20 or more converging lenses, placed in line with one another, so that both lenses refract the
light in turn. The result is to produce an image that is magnified more than either lens
could magnify alone. Light illuminating the object first passes through a short focal
length lens or lens group, called the objective, and then travels on some distance before
being passed through a longer focal length lens or lens group, called the eyepiece. A lens
25 group is often simply referred to singularly as a lens. Usually these two lenses are held in
paraxial relationship to one another, so that the axis of one lens is arranged to be in the
same orientation as the axis of the second lens. It is the nature of the lenses, their
properties, their relationship, and the relationship of the objective lens to the object that
determines how a highly magnified image is produced in the eye of the observer.

30

The first lens or objective, is usually a small lens with a very small focal length. A
specimen or object is placed in the path of a light source with sufficient intensity to

illuminate as desired. The objective lens is then lowered until the specimen is very close to, but not quite at the focal point of the lens. Light leaving the specimen and passing through the objective lens produces a real, inverted and magnified image behind the lens, in the microscope at a point generally referred to as the intermediate image plane. The
5 second lens or eyepiece, has a longer focal length and is placed in the microscope so that the image produced by the objective lens falls closer to the eyepiece than one focal length (that is, inside the focal point of the lens). The image from the objective lens now becomes the object for the eyepiece lens. As this object is inside one focal length, the second lens refracts the light in such a way as to produce a second image that is virtual,
10 inverted and magnified. This is the final image seen by the eye of the observer.

Alternatively, common infinity space or infinity corrected design microscopes employ objective lenses with infinite conjugate properties such that the light leaving the objective is not focused, but is a flux of parallel rays which do not converge until after passing through a tube lens where the projected image is then located at the focal point of
15 the eyepiece for magnification and observation. Many microscopes, such as the compound microscope described above, are designed to provide images of certain quality to the human eye through an eyepiece. Connecting a Machine Vision Sensor, such as a Charge Coupled Device (CCD) sensor, to the microscope so that an image may be viewed on a monitor presents difficulties. This is because the image quality provided by the
20 sensor and viewed by a human eye decreases, as compared to an image viewed by a human eye directly through an eyepiece. As a result, conventional optical systems for magnifying, observing, examining, and analyzing small items often require the careful attention of a technician monitoring the process through an eyepiece. It is for this reason, as well as others, that Machine-Vision or computer-based image displays from the
25 aforementioned image sensor displayed on a monitor or other output display device are not of quality perceived by the human observer through the eyepiece.

SUMMARY OF THE INVENTION

The following presents a simplified summary of the invention in order to provide a
30 basic understanding of some aspects of the invention. This summary is not an extensive overview of the invention. It is intended to neither identify key or critical elements of the

CLAIMS

What is claimed is:

1. An imaging system, comprising:
a sensor having one or more receptors; and
an image transfer medium to scale the one or more receptors to an object field of view.
2. The system of claim 1, the image transfer medium providing a k-space filter that correlates a pitch associated with the one or more receptors to a diffraction-limited spot within the object field of view.
3. The system of claim 2, the pitch being unit-mapped to about the size of the diffraction-limited spot within the object field of view.
4. The system of claim 1, the image transfer medium further comprising at least one of an aspherical lens, a multiple lens configuration, a fiber optic taper, an image conduit, and a holographic optic element.
5. The system of claim 1, the sensor further comprising an M by N array of pixels associated with the one or more receptors, M and N representing integer rows and columns respectively, the sensor further comprising at least one of a digital sensor, an analog sensor, a Charge Coupled Device (CCD) sensor, a CMOS sensor, a Charge Injection Device (CID) sensor, an array sensor, and a linear scan sensor.
6. The system of claim 1, further comprising a computer and a memory to receive an output from the sensor, the computer at least one of stores the output in the memory, performs automated analysis of the output in the memory, and maps the memory to a display to enable manual analysis of an image.

7. The system of claim 1, further comprising an illumination source to illuminate one or more non-luminous objects within the object field of view, the illumination source further comprises at least one of a Light Emitting Diode, wavelength-specific lighting, broad-band lighting, continuous lighting, strobed lighting, Kohler illumination, Abbe illumination, phase-contrast illumination, darkfield illumination, brightfield illumination, Epi illumination, coherent light, non-coherent light, visible light and non-visible light, the non-visible light being suitably matched to a sensor adapted for non-visible light.
8. The system of claim 7, the non-visible light further comprising at least one of infrared and ultraviolet wavelengths.
9. The system of claim 1, further comprising an associated application, the application including at least one of imaging, control, inspection, microscopy automated analysis, bio-medical analysis, cell colony counting, histology, frozen section analysis, cellular cytology, Haematology, pathology, oncology, fluorescence, interference, phase analysis, biological materials analysis, particle sizing applications, thin films analysis, air quality monitoring, airborne particulate measurement, optical defect analysis, metallurgy, semiconductor inspection and analysis, automated vision systems, 3-D imaging, cameras, copiers, FAX machines and medical systems applications.
10. A method of producing an image, comprising:
 - determining a pitch size between adjacent pixels on a sensor;
 - determining a resolvable object size in an object field of view; and
 - scaling the pitch size through an optical medium to correspond with the resolvable object size.

11. A machine vision system, comprising:
 - an imaging system for collecting image data from a product or process, comprising:
 - a sensor having one or more receptors; and
 - at least one optical device to direct light from an object field of view to the one or more receptors of the sensor, the at least one optical device provides a mapping of receptor size to about a size of a diffraction limited object appearing in the object field of view; and
 - a controller that receives the image data and employs the image data in connection with fabrication or control of the product or process.
12. The machine vision system of claim 11 being employed in a semiconductor-based fabrication system.

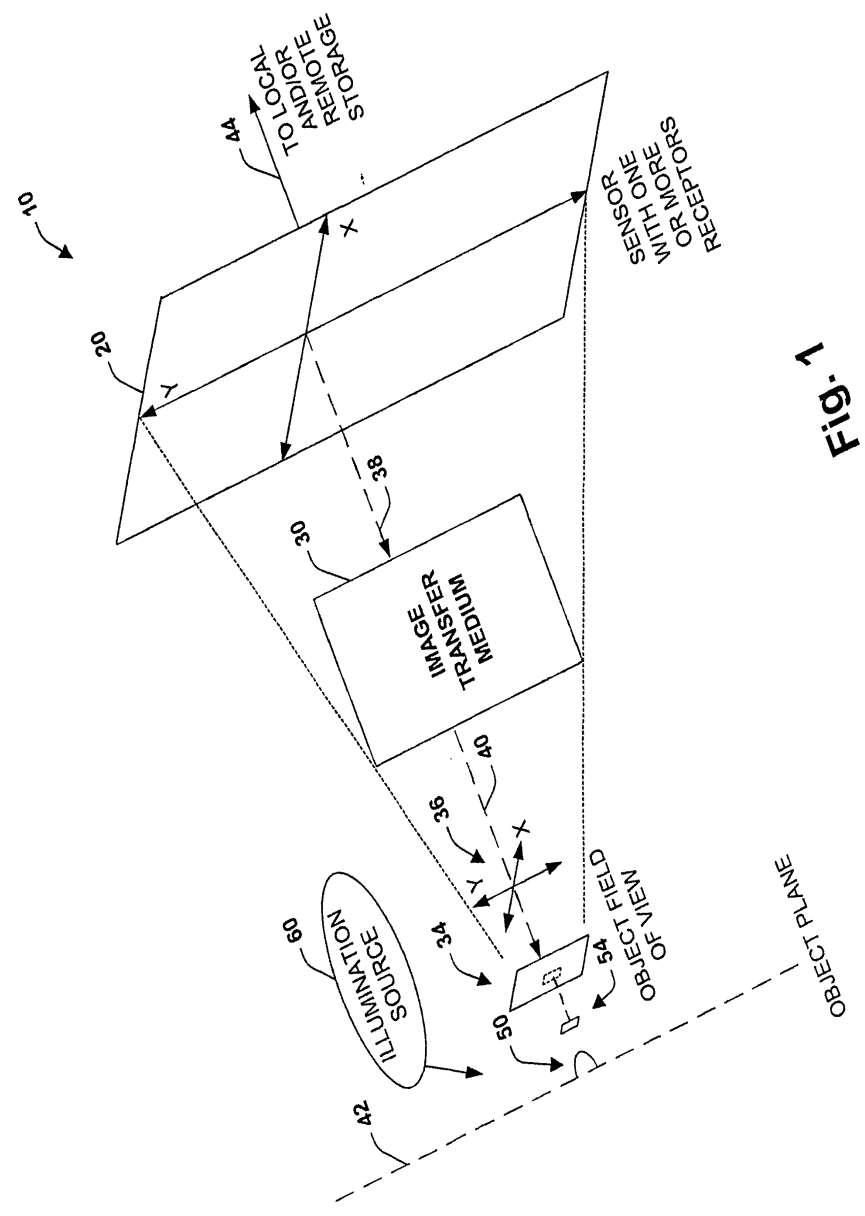


Fig. 1

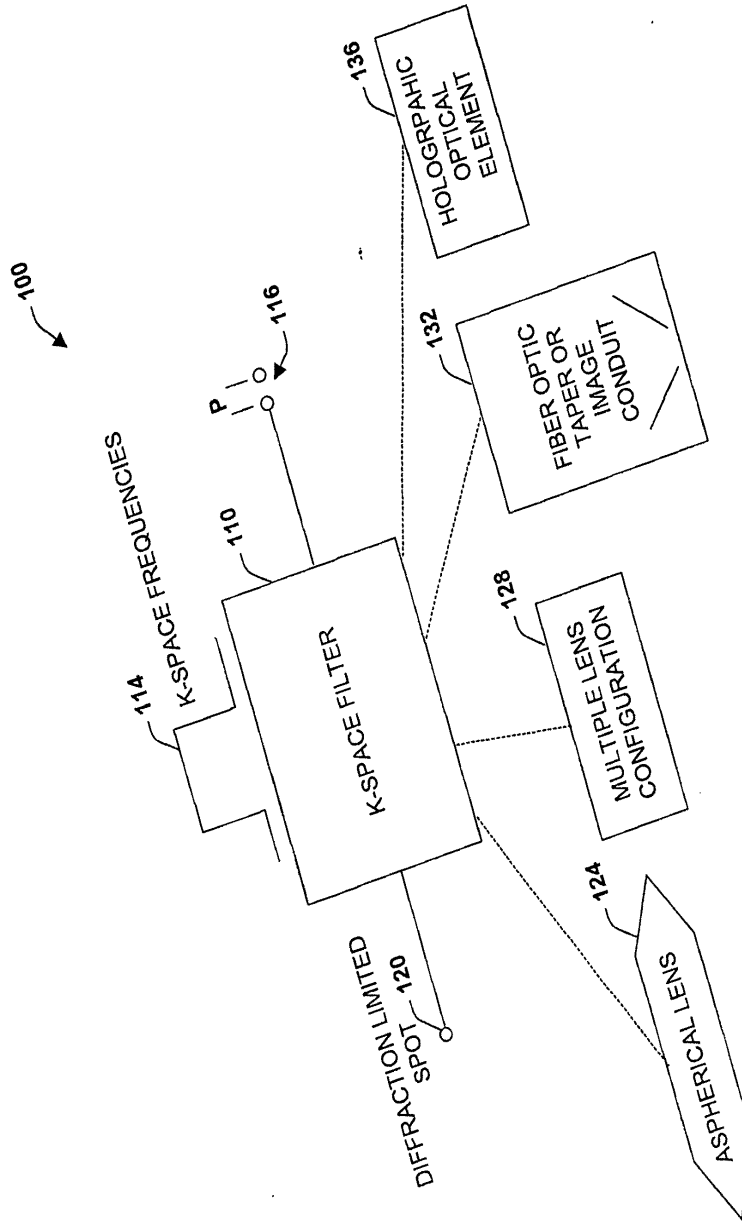
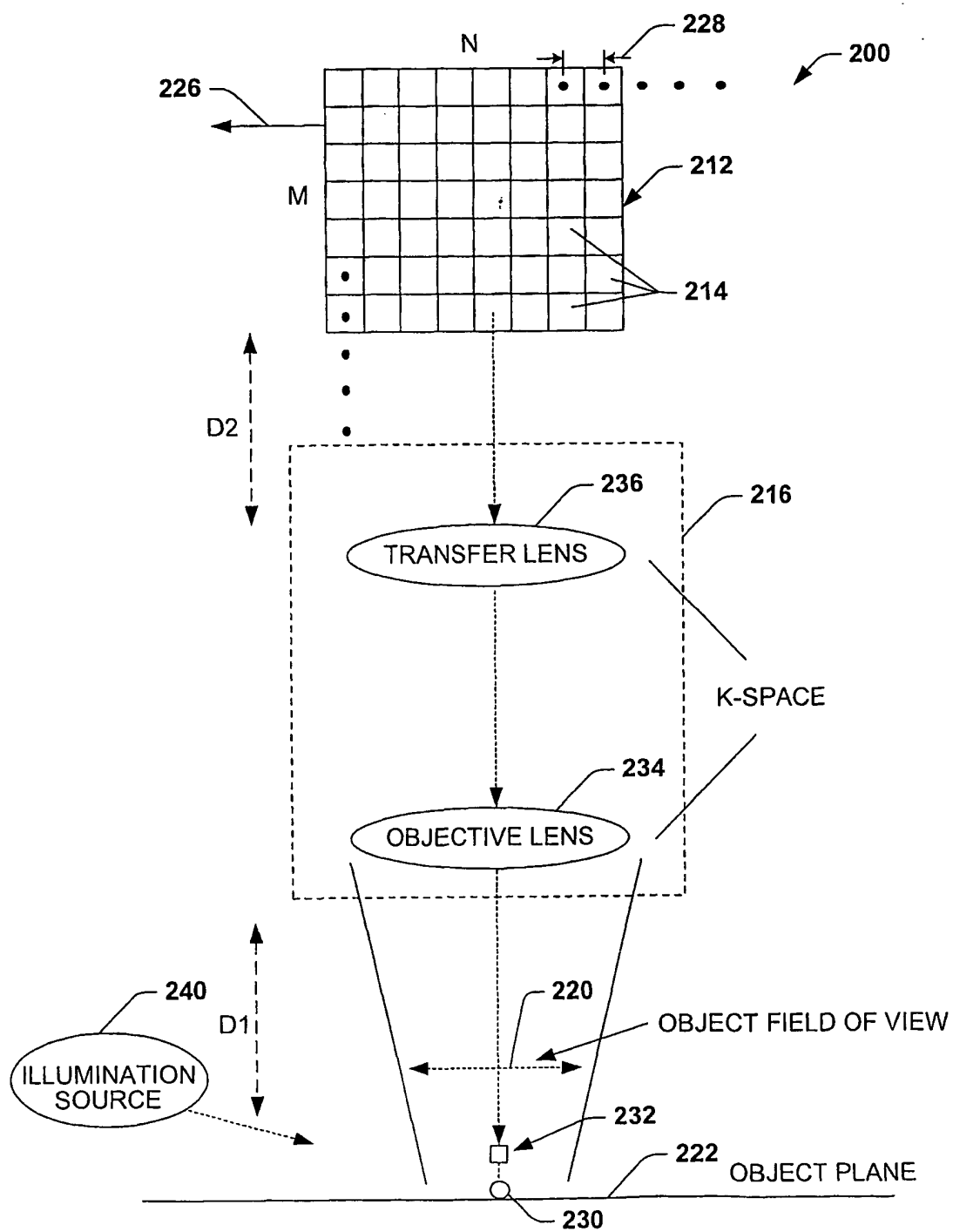


Fig. 2

**Fig. 3**

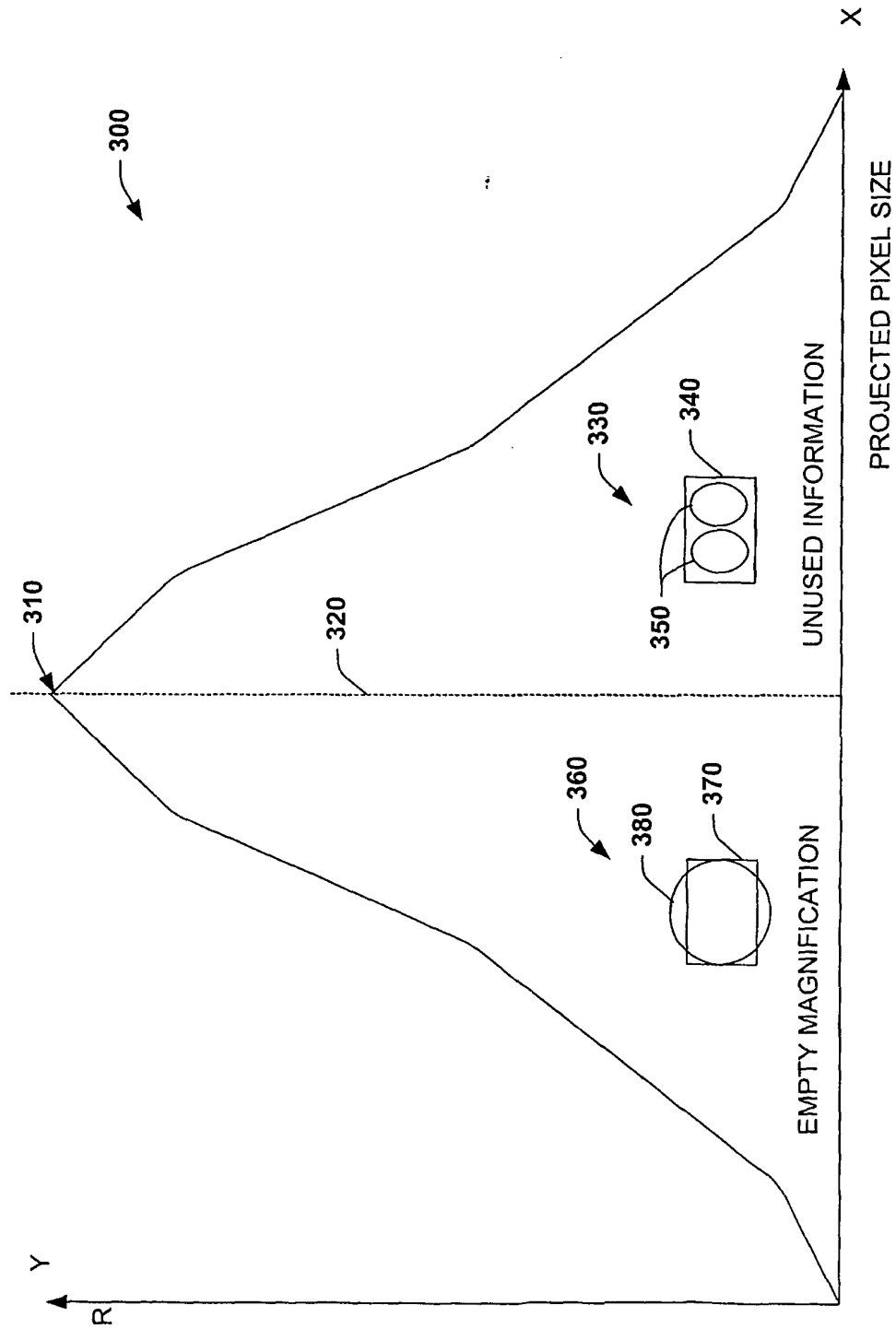


Fig. 4

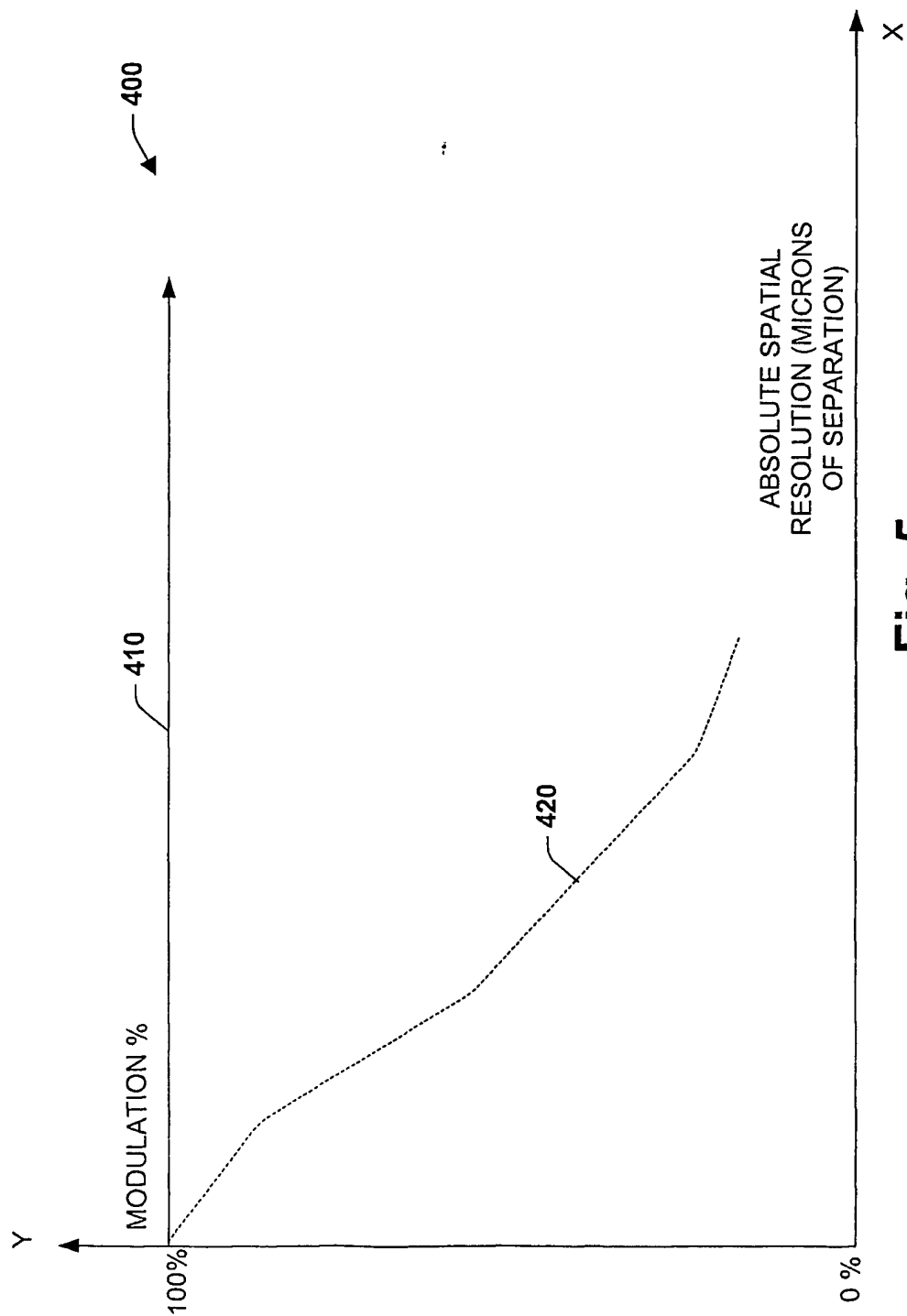


Fig. 5

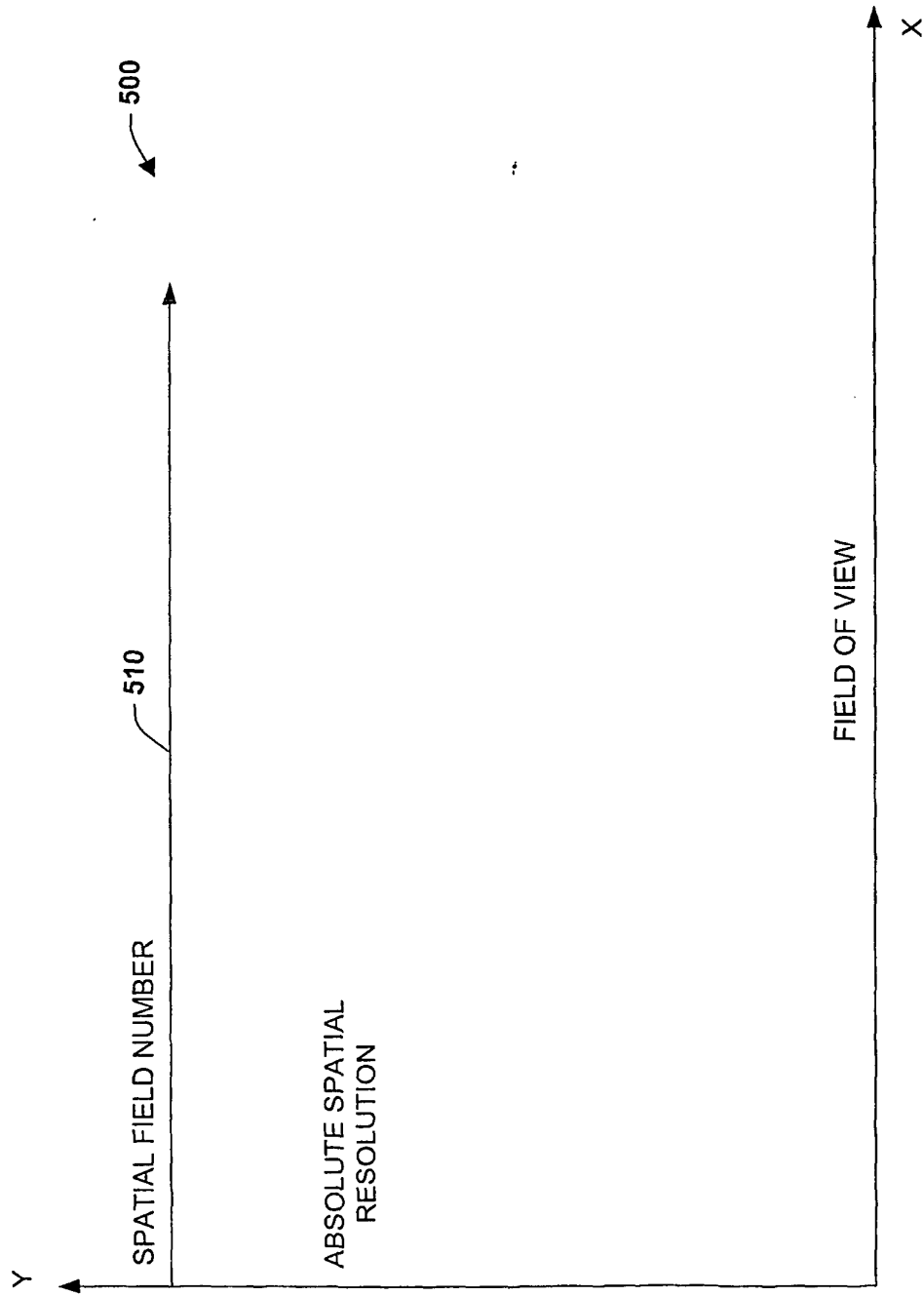
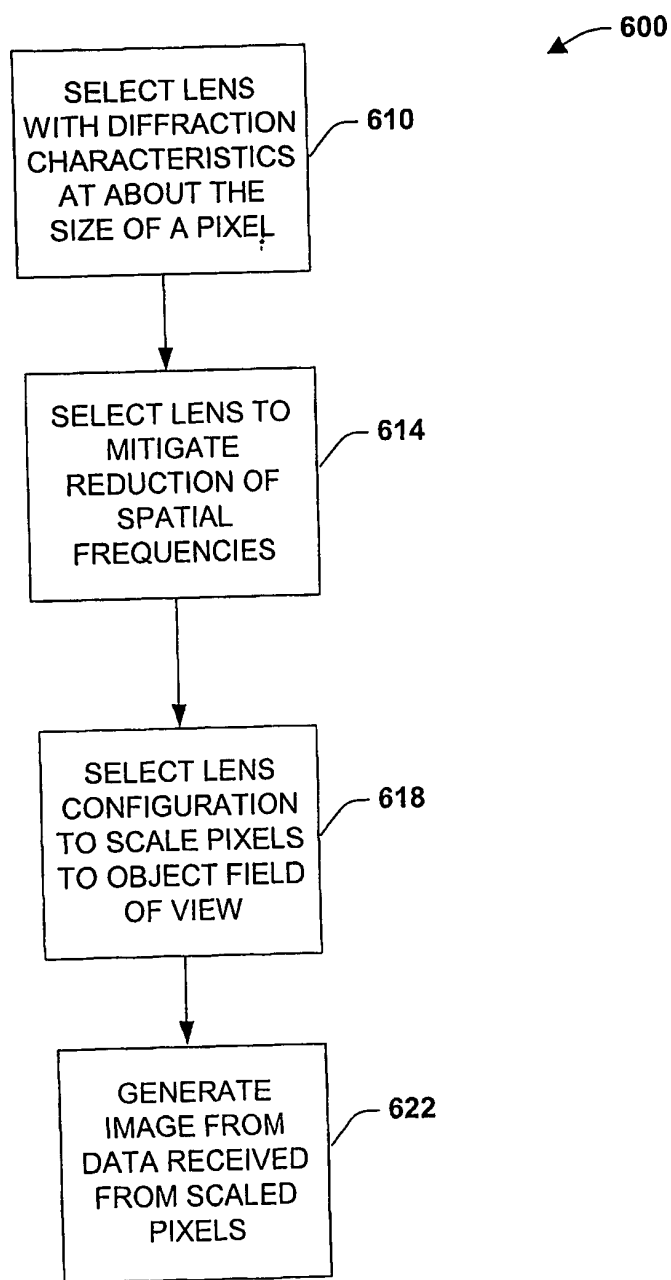
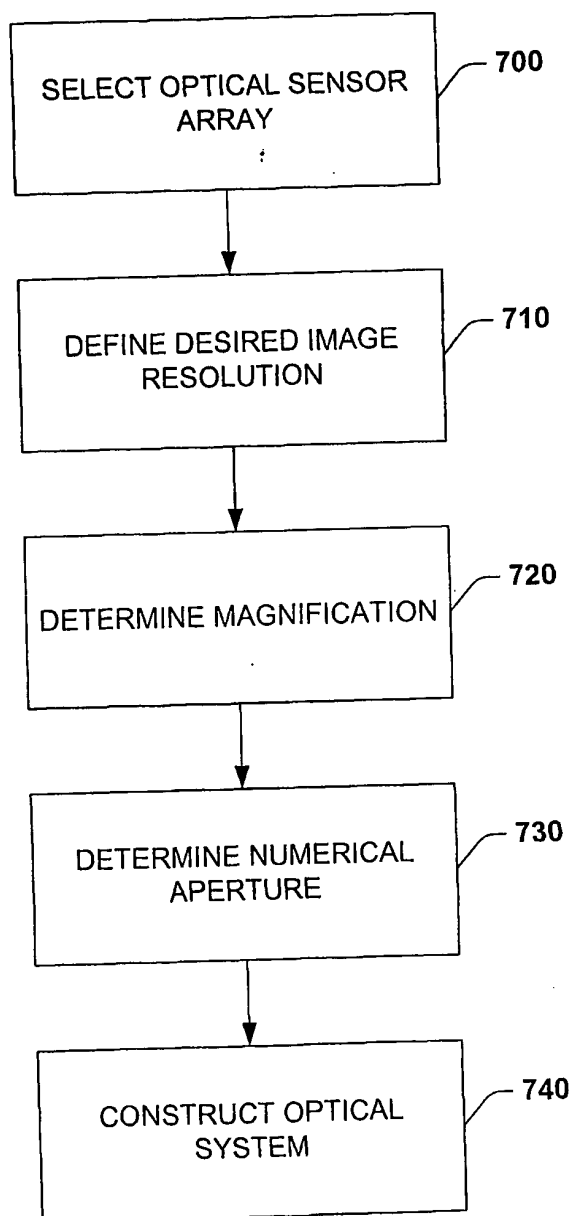
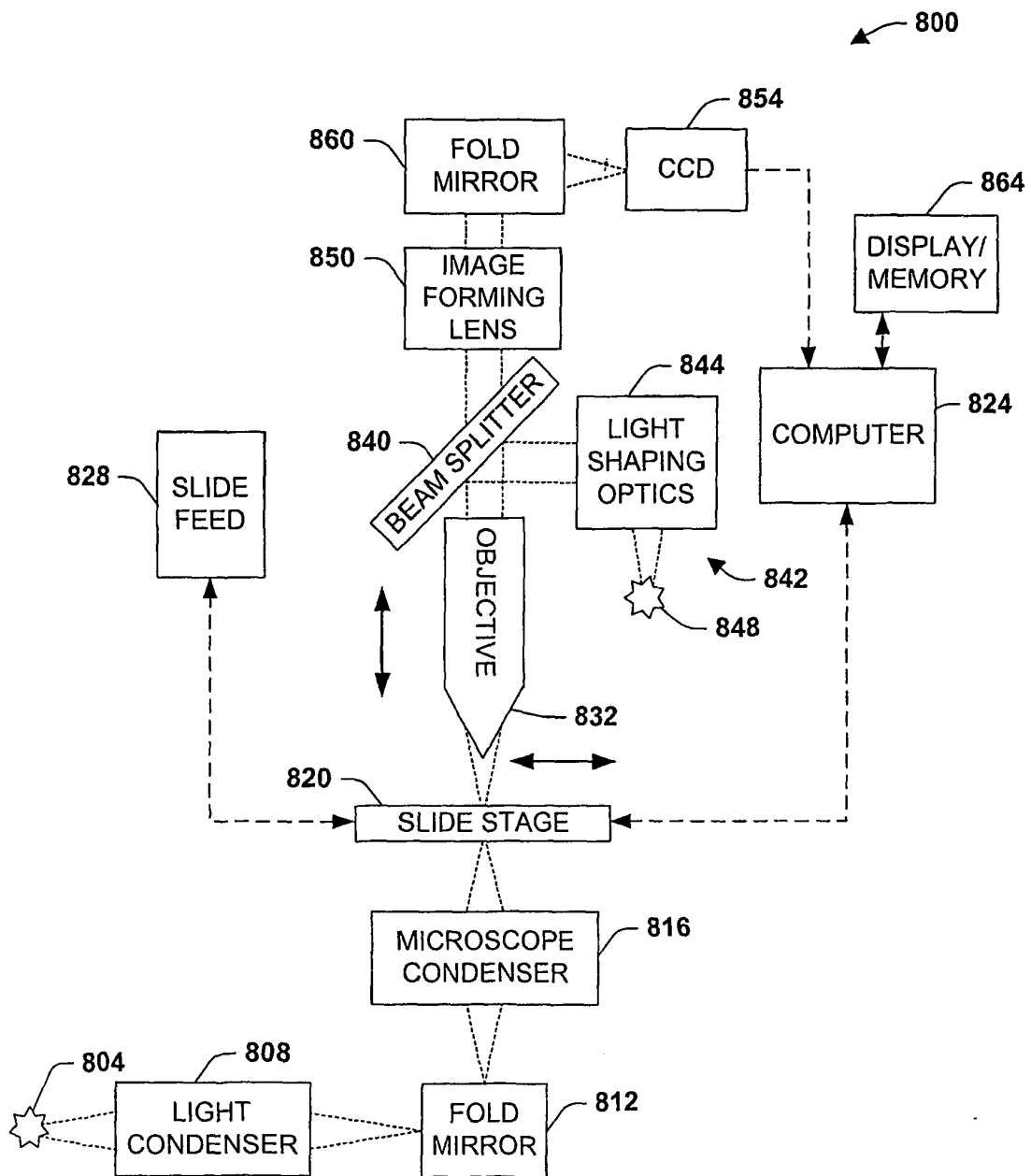
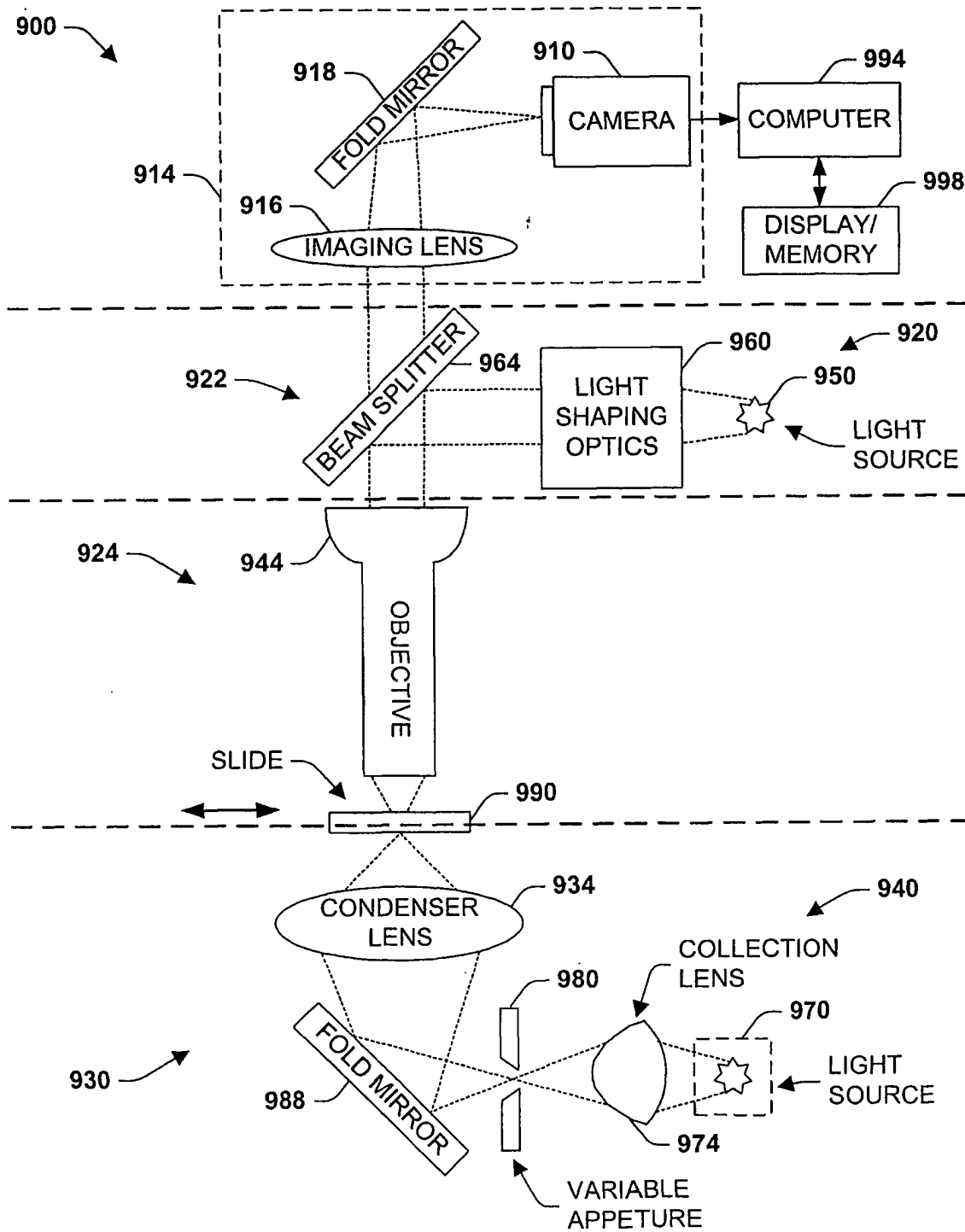


Fig. 6

**Fig. 7**

**Fig. 8**

**Fig. 9**

**Fig. 10**

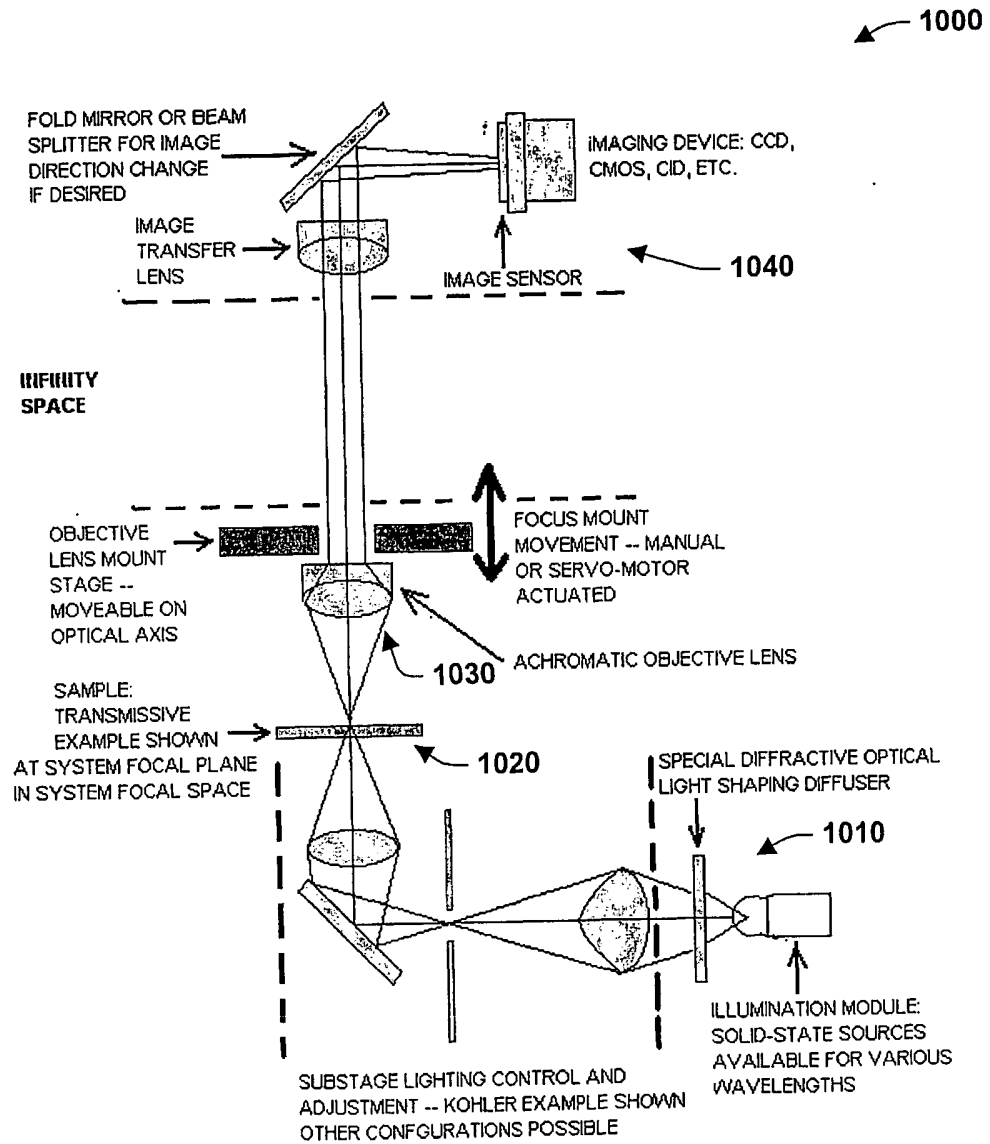


Fig. 11

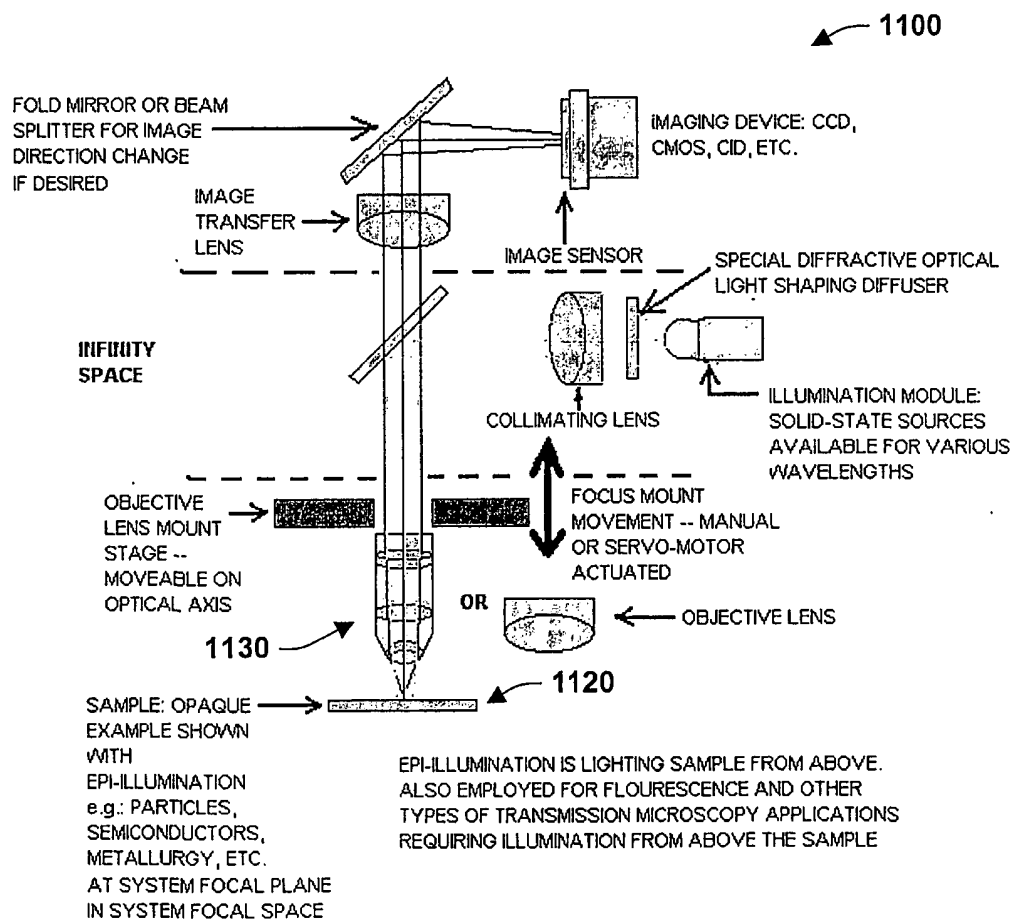


Fig. 12

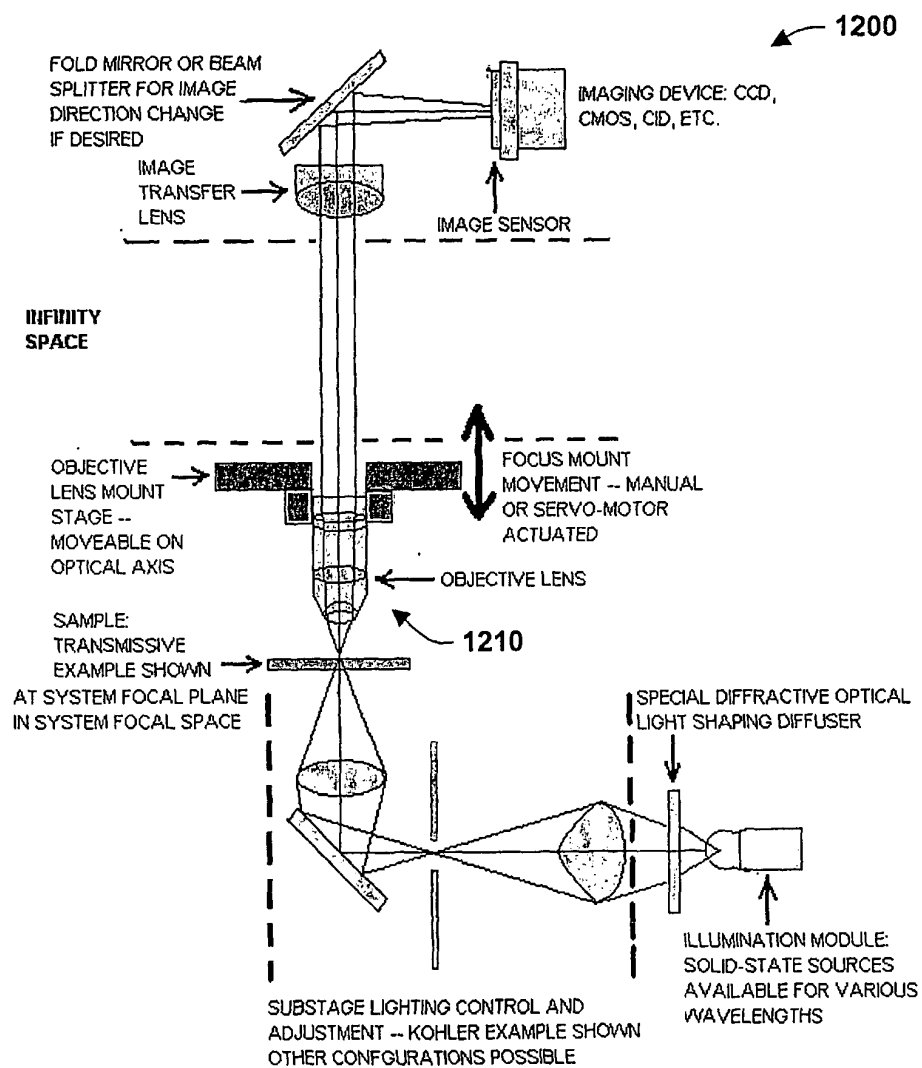
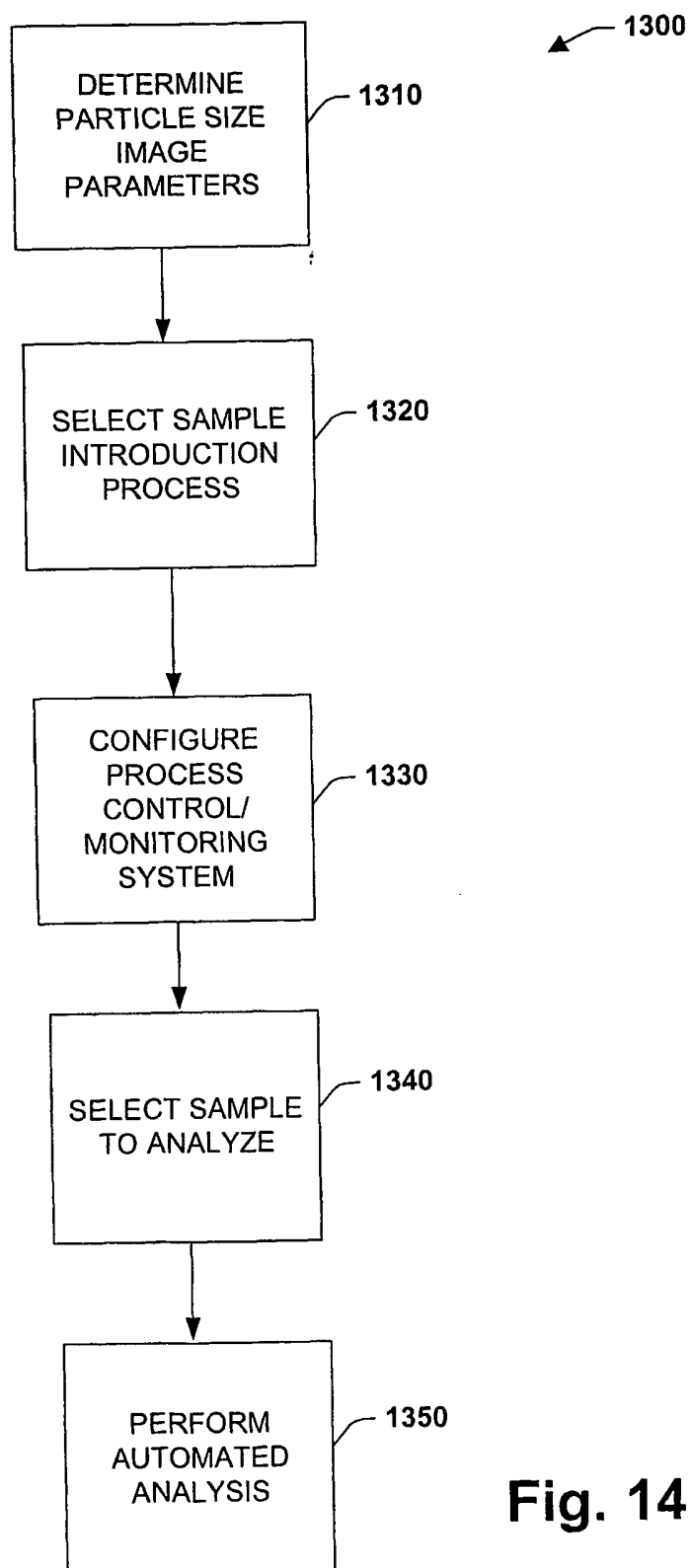
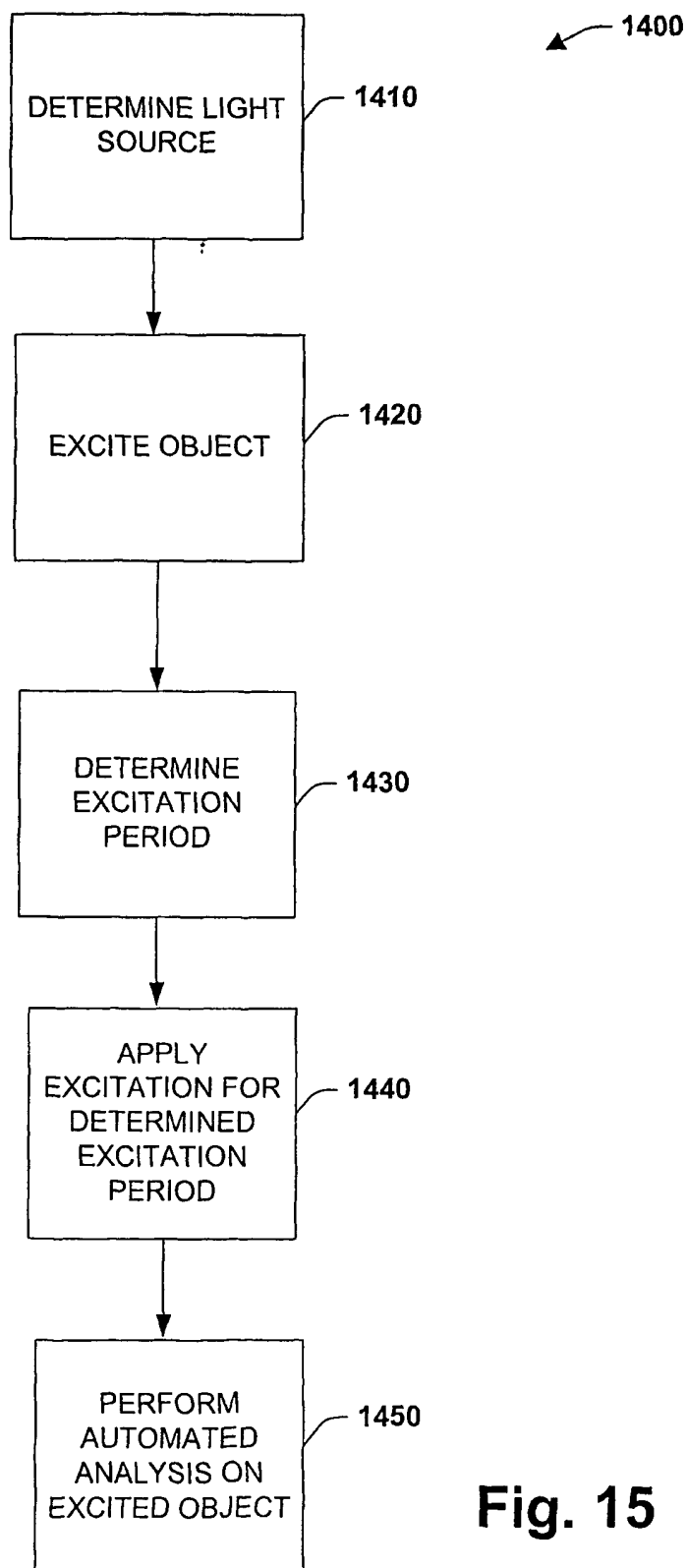
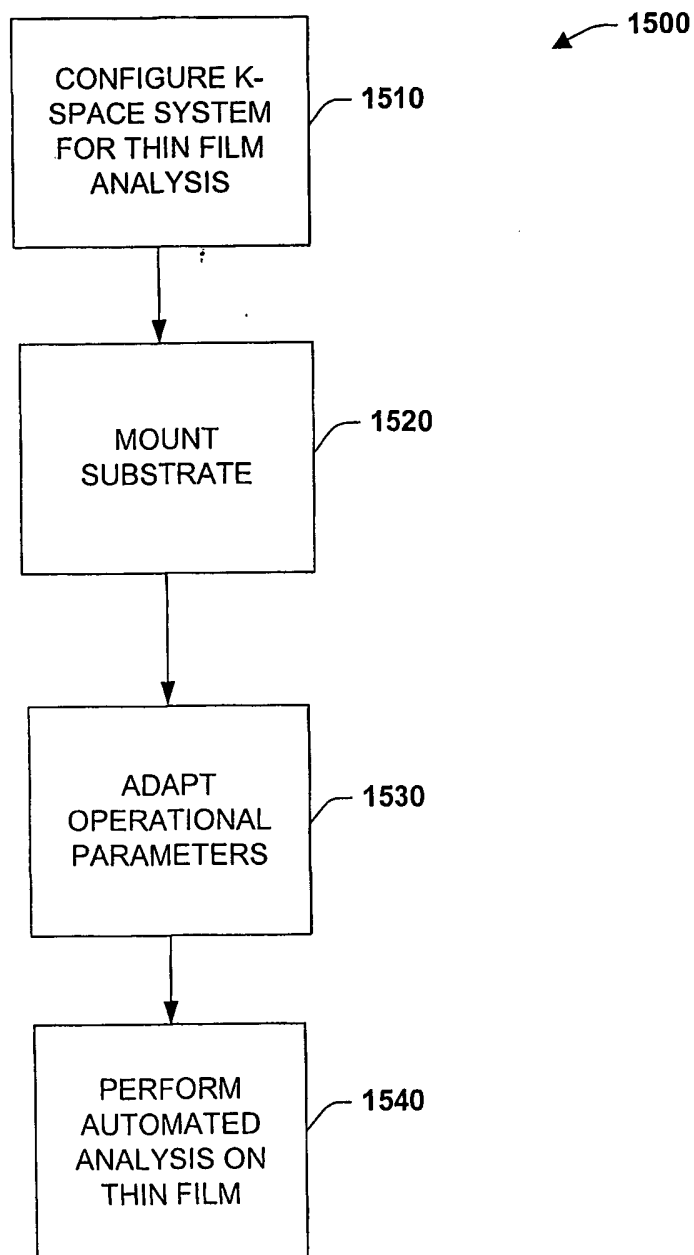
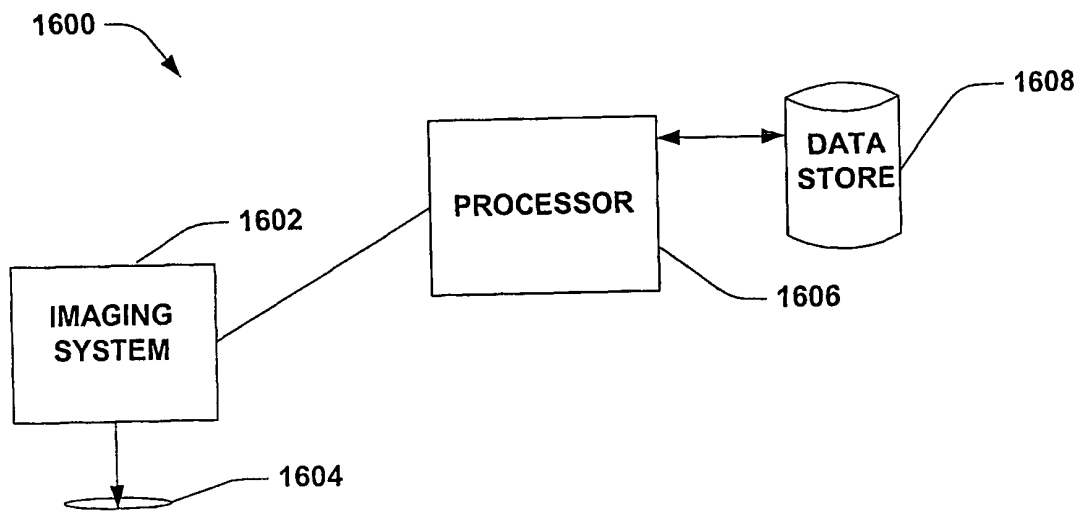


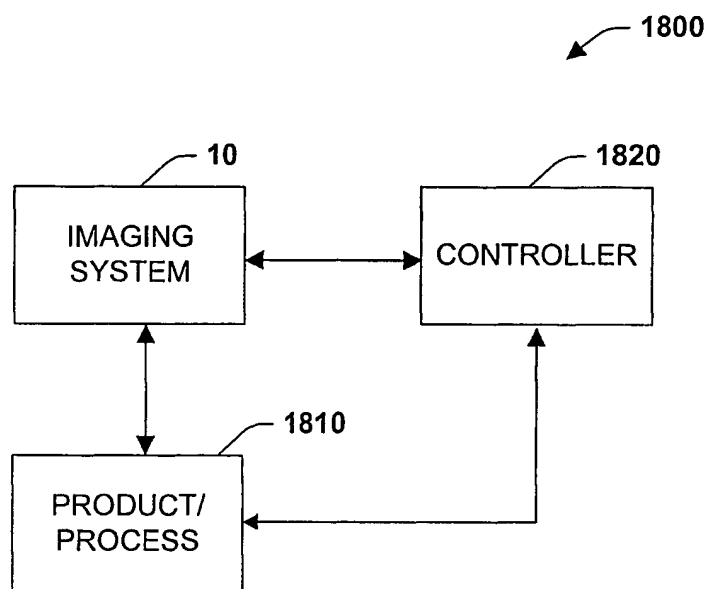
Fig. 13

**Fig. 14**

**Fig. 15**

**Fig. 16**

**Fig. 17**

**Fig. 18**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US02/21392

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : H01L 27/00; G02B 27/40; G06K 9/76

US CL : 250/208.1, 201.3; 359/15; 382/210

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 250/208.1, 201.3, 201.9; 359/15, 9, 26; 382/210, 134

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,973,844 A (BURGER) 26 October 1999 (26.10.1999), see the entire document.	1-12
X	US 5,198,653 A (SHEN et al.) 30 March 1993 (30.03.1993), see the entire document.	1-5
A	US 6,248,988 B1 (KRANTZ) 19 June 2001 (19.06.2001), see the entire document.	1-12

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier application or patent published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

09 September 2002 (09.09.2002)

Date of mailing of the international search report

12 NOV 2002

Name and mailing address of the ISA/US

Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231

Facsimile No. (703)305-3230

Authorized officer

SEUNG C. SOHN

Telephone No. (703) 308-4093

INTERNATIONAL SEARCH REPORT

PCT/US02/21392

Continuation of B. FIELDS SEARCHED Item 3:

EAST

SEARCH TERMS:

(k-space or reciprocal-space) near filter

"object field of view"

"field of view"

((k or reciprocal) near space) near filter

"modulation transfer function"

"modulation transfer function" and (((recept\$4 or pixel\$2 or sens\$4) near (scal\$4 or map\$4 or siz\$4 or project\$4 or match\$4 or reduc\$4)) and 250/\$.ccls.) and microscop\$4)

unit-map\$4 or (unit near map\$4)

((microscop\$4.ti. and (250/\$.ccls or 359/\$.ccls.)) and ccd) and led) and (wavelength-specific or broadband or continuous or strobed or kohler or abbe or phase-contrast or darkfield or brightfield or epi)

pitch\$2 with pixel\$2

"working distance"